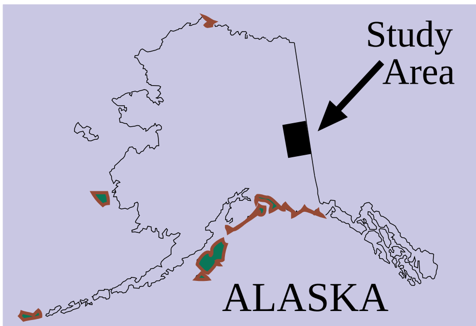
Placer Gold Mining in Alaska — Cooperative Studies on the Effect of Suction Dredge Operations on the Fortymile River



Background

Alluvial gold was first discovered in the Fortymile River Mining District (FMD) in 1886 and has been placer mined there ever since. Essentially all of the mining in FMD has been placer. During the lifetime of the district more than 500,000 oz of gold have been produced. Economic and environmental considerations along the Fortymile River corridor have recently restricted most placer mining activities to relatively small suction dredge operations that focus on the recovery of gold from within-stream bottom sediments. The suction dredge removes the river bottom material, usually down to bedrock, and passes it through floating sluice boxes at the water's surface. This process saves the dense sediment and cobble fraction while redepositing less dense material back into the stream (see companion USGS Fact Sheet 154-97).

The management of the region and its resources is complex due to the many diverse land-use options. In 1980, the Fortymile River and many of its tributaries received Wild and Scenic River status. Jurisdiction of the land bordering the watershed continued to be the responsibility of the Bureau of Land Management (BLM). The State of Alaska Department of Natural Resources (AK-DNR) has jurisdiction over the management of the river's recreation (rafting, canoeing, and fishing) and mining. The U.S. Environmental Protection Agency (EPA) is also involved because mining discharges require compliance with the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act. Finally, both sport and subsistence hunting are important in the region and are managed by several Federal and State agencies.

The Issue

Concern has been raised that the dredge operations may be increasing the metal load and turbidity of the river while decreasing the number and diversity of aquatic biota. Whereas dredge operations do resuspend the bottom sediment, the magnitude of this disturbance on stream metal loading is unknown, as is its possible impact on stream biota. Furthermore, it is unknown what effect the dredge operations may have on the transport and redistribution of metals—some of which (for example, arsenic, copper, and zinc) have environmental importance. State and Federal regulations require that the degree of adverse impact, if any, be quantified. The U.S. Geological Survey and the Alaska Department of Natural Resources are cooperating in a project to provide the scientific data for upcoming decisions that involve State and Federal land-use options and their regulations. The project has three main objectives: (1) using both a geologic and a hydrologic framework, define the relative contribution of the various natural sources of arsenic and other environmentally important metals to the landscape, (2) assess the regional geochemical

USGS and Alaska State scientists collecting stream flow and water chemistry information on Bullion Creek, a tributary of the Fortymile River.

distribution of arsenic and metals in soils, vegetation, and surface water (including arsenic speciation) in selected major watersheds, and (3) assist the State and EPA in the arsenic risk-assessment process.

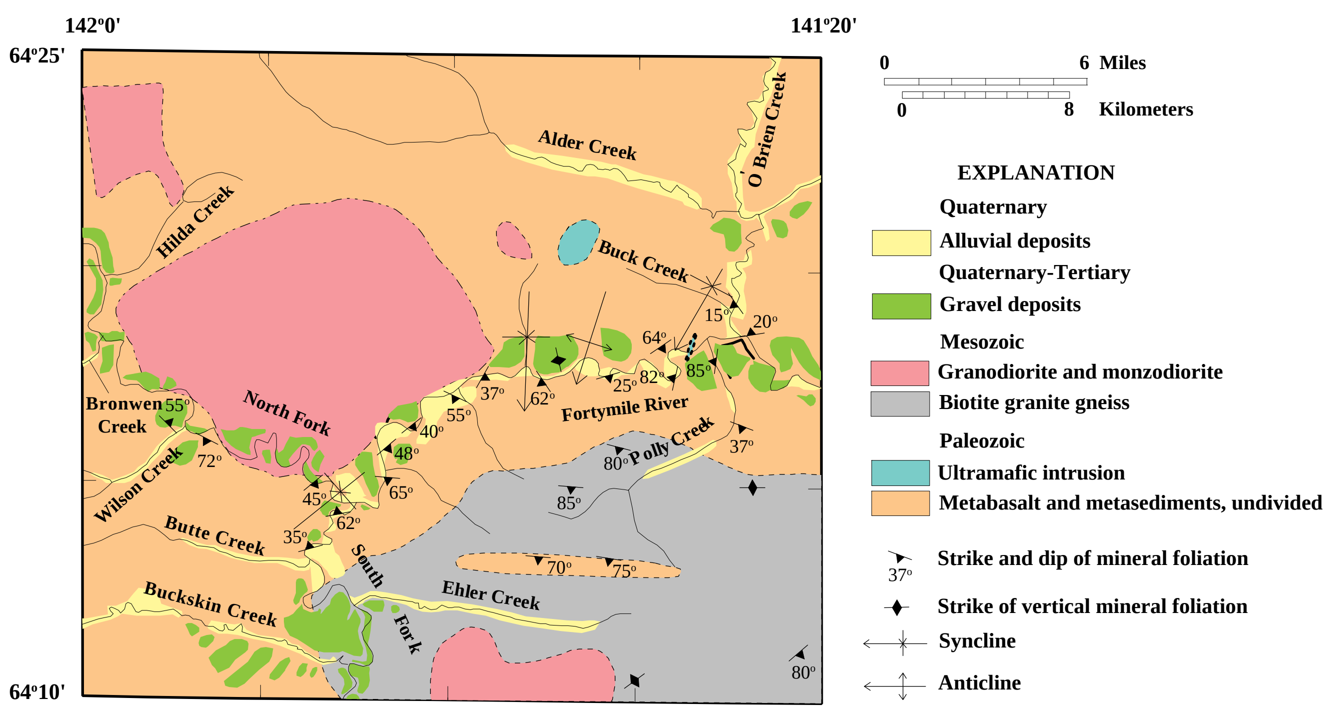
The placer dredge operations must meet certain minimum operational criteria in order to receive State mining permits. Permitting is based on use of approved mining methods, camp placement and structure, and discharge to the river of mining wastes. In November 1996, the State of Alaska and EPA released the new NPDES discharge guidelines under a General Permit (GP) for all placer mining. The blanket discharge rules differ somewhat depending on the size of the operation, but contain, among other things, a temporary waiver to the proposed EPA drinking water standard for arsenic (0.18 micrograms per liter). A recent court decision has mandated that monitoring be conducted of the "fourteen toxic metals found most frequently in Alaska placer mine effluent(s)." Further, permits require the measurement of "natural background" levels for turbidity. The State and EPA will use information from this study to refine the language of future General Permits and to establish the methods and protocols used to evaluate compliance to the GP.

Task Objectives

The "fourteen toxic metals" targeted for monitoring by the court decision are aluminum, antimony, arsenic, calcium, copper, chromium, cadmium, magnesium, mercury, nickel, lead, selenium, silver, and zinc. Arsenic is of particular concern because anomalously high concentrations have been found in soil, sediment, and surface water during the preparation of Environmental Impact Statements for the region.

Arsenic migration is limited by high levels of sulfide in reducing environments and by its tendency to sorb onto clays, hydroxides, and organic matter. The source of the arsenic is geologic (as opposed to anthropogenic) and is known to be associated with sulfides (especially arsenopyrite) in both the metasediments and metavolcanics of Paleozoic age, as well as younger intrusive igneous bodies. Other than sulfide oxidation, it is unknown how arsenic is mobilized, how much of an impact suction dredge placer mining techniques may accentuate arsenic transport, and whether the presence of arsenic poses a threat to aquatic life, wildlife, or humans.

Important to this study's assessment will be the evaluation of the flux and biogeochemical cycling of arsenic between the terrestrial and aquatic phases. In addition to studying water-rock processes that mobilize arsenic, this project is also examining other factors that affect arsenic bioavailability to the environment (for example, in sites that are mined vs. unmined; vegetated vs. barren; saturated (permafrost) vs. drained; forested vs. muskeg).



Geology of the North, South, and main stem of the Fortymile River study area. Tributaries visited as part of the June 1997 study are labeled.

Geologic Setting

Bedrock and alluvium control the minerals and chemical elements available to enter the hydrologic and biologic systems. Therefore, understanding the geologic framework of FMD is the first step in assessing the effect of suction dredge operations on the Fortymile River. One of the goals of this project is to chemically characterize the bedrock of the area in order to understand its role in determining the composition of the river and stream waters which flow across it. These waters, in turn, flow into the Fortymile River drainage and form the "background" necessary to evaluate the effect of the dredge operations on the water chemistry and turbidity.

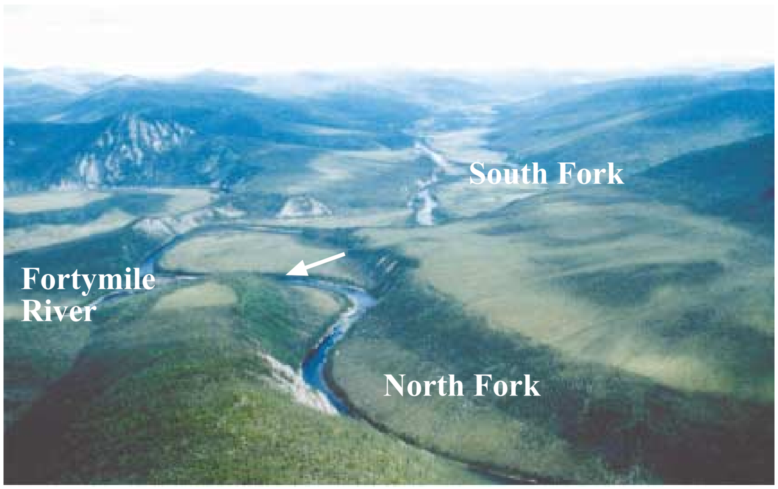
The bedrock of the Fortymile Mining District is made up of volcanic and sedimentary rocks of Paleozoic age that have been intruded by younger granitic rocks. The volcanic rocks were originally basalt similar to that formed in modern marine environments. The original sedimentary rocks were variable in composition and are also similar to those seen in modern marine environments. This entire package of rocks experienced regional mountain-building event(s) during the Jurassic Epoch of the Mesozoic Era in which the rocks were metamorphosed, deformed, and invaded by granite. The regional tectonic mountain-building event(s) caused several periods of folding of the rocks, the latest of which produced regional north-northeast oriented anticlines and synclines (see geologic map).

Recent geologic mapping has outlined several distinct types of alluvial deposits that range in age from Tertiary to Recent. During the Tertiary Epoch, numerous benches were cut into the bedrock by the forces of erosion. These benches have Tertiary- to Quaternary-age gravel deposits upon them, which locally host placer gold (see geologic map). Along the banks of the Fortymile River, Quaternary alluvial gravel, sand, and silt deposits have been the main source of the placer gold mined to date and are the principal target for the dredge mining operations along the river.

Progress

Geologic mapping is being conducted that is specific to the study area. An understanding of the geologic framework is a critical component of the regional geoenvironmental analysis. In addition, results of chemical analyses of water samples are being interpreted in the context of regional and local geology, emphasizing the importance of water-rock interactions as a determining factor in water quality, and the fate and transport of elements of interest. Numerical modeling of the results are being conducted to further our understanding of the geochemical processes which are active in the FMD area, and the cumulative effect of those processes on water quality.

We will attempt to distinguish between natural background levels of elements in stream waters and those levels that consist of both a natural and an anthropogenic (mining-related) component. The enhancement or retardation of metal mobility directly affects regional geochemical backgrounds. Vegetation and soil sampling, and their chemical analysis, have been conducted at selected sites in order to define metal mobility and bioavailability. For example, geologic areas with oxidizing pyritic material are expected to enhance metal cation mobility (ambient pH decrease) and uptake by vegetation would be expected. Incorporation of metals in plant material often promotes metal cycling in both terrestrial and aquatic ecosystems. Because the form (species) of an element also greatly affects both bioavailability and potential toxicity, analyses of both arsenic(III) and arsenic(V) are currently being conducted.



Aerial view looking south up the South Fork Fortymile River in east-central Alaska. An example of the gravel deposit benches is indicated by arrow. This picture is typical of the rolling mountain/canyon topography of the Alaska Interior Highlands Ecoregion.

Further Reading

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